Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

AN EXAMINATION OF THE POLICY OF RESTOCKING THE INLAND WATERS WITH FISH[1]

PROFESSOR W. M. SMALLWOOD

SYRACUSE UNIVERSITY

THE large sums of money annually expended by both the National Government and the several states in fish propagation fall into two general fields of activity, the marine and the freshwater. The freshwater activity in turn may for convenience be divided into the production of food and game fish.

It is always proper to examine the conditions which influence restocking; and just at this time it is especially fitting to enquire into the efficacy of the methods. The technique involved in securing the eggs and their care during hatching have been well worked out. It was a marked step in advance when these modern methods were first put into practice. The money used in carrying out modern methods in the many fish hatcheries is efficiently expended so far as the writer has been able to determine. The fundamental scientific problems involved have been solved so that the regular fish foreman can successfully direct and supervise all of the steps in the process.

After the eggs have been hatched and the young fed for a certain length of time, they are distributed to the ponds and streams. The last act in the series is the one concerning which we know the least. In order to gain an insight into the actual conditions, a typical Adirondack pond was selected for study.

The whitefish is the only species that has become at all abundant as a result of the policy of the state. The fault does not seem to be connected with the number of fingerlings placed in this lake, for the state has, indeed, been generous. The problem that confronted the writer was to discover the cause or causes for the obvious failure of this lake to support an abundance of fish after these thirty years of restocking.

---

[1] Contributions from the Zoological Laboratory, Liberal Arts College, Syracuse University, C. W. Hargitt, director.

In the study of the life of any given body of water or area of land, a number of fundamental relationships have to be established before an effective detailed study can be made. After examining the conditions in several Adirondack ponds and lakes, the writer felt the necessity of examining the broader aspects of the problem with the hope that such a study might reveal some of the

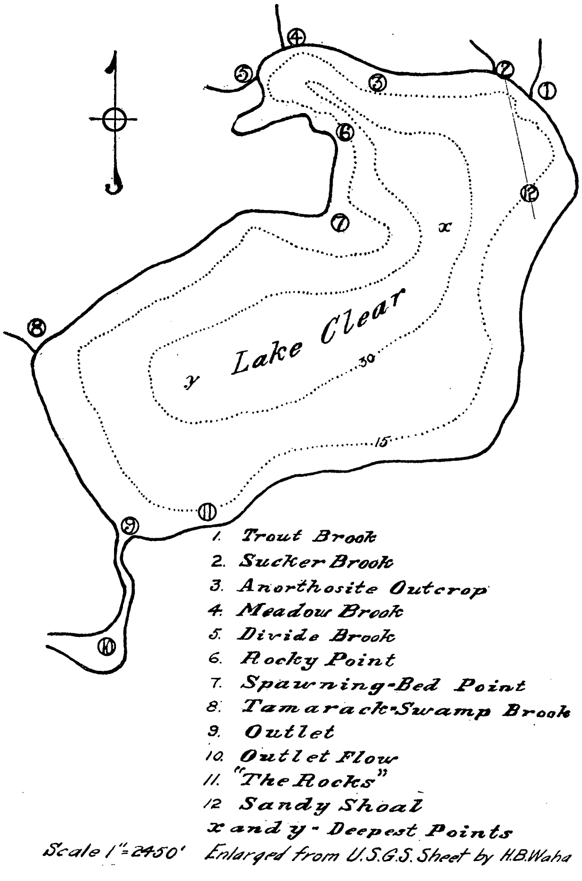

Fig. 1.

causes that are influencing the present general food supply for fishes, the future food supply, the plant growth and other general problems related to the successful restocking of waters in the Adirondacks.

Such a study implies that one understand the soil and its origin. The Adirondack ponds are noteworthy for their abundance of sand. This sand is in the final analysis responsible for much of the modern life of these same ponds and lakes to-day. The geological history of the Adirondacks, especially its glaciology, is just becoming well understood by the experts. For the purposes of this paper it is simply necessary to keep in mind the fact that as the glacier receded, the Adirondacks were surrounded by a ring of ice. Within this ring of ice first the higher peaks and later the lower areas were exposed. The general result was that there were formed in succession a series of temporary glacial lakes, the remnants of which constitute the present Adirondack lakes and ponds.

Lake Clear, formerly known as Big Clear Pond, is located near Lake Clear R. R. Junction. It is at the headwater of the Saranac Lake system, so is free from the usual migration that takes place when one pond receives an outlet from another. The lake contains nearly 1,000 acres of water, which comes entirely from springs and mountain brooks. The water is clear, cool and pure—an ideal freshwater pond for restocking, one would say. What has thirty years of restocking by the state accomplished? The following table indicates that this pond has received 17,535,850 food and game fish.

In some regions, no less than eight successive lakes have been revealed by the recent critical studies of glaciologists. The net result is the accumulation of vast quantities of sand from which most of the organic food has been removed.

Lake Clear is one of the remnants of a much larger glacial lake, the shores of which are easily made out. This lake it has been proposed to call Lake St. Germain.[2]

---

[2] From the unpublished account of Lake Clear by Mr. Harold Alling.

FISH PLANTED IN LAKE CLEAR

	Brook Trout	Lake Trout	Rainbow Trout	Brown Trout	White Fish
1887	20,000	30,000			
1888	20,000	50,000			
1889	40,000	150,000		5,000	
1890	25,000	100,000		1,000	
1891	25,000				
1892	20,000	100,000			
1893	20,000	100,000			
1894	15,000	15,000			
1895	35,000	50,000			
1896	35,000	50,000			
1897	11,000	10,000			100,000
1898	1,600	10,000			
1899	5,000	10,000			
1900	36,000	35,000	3,000		600,000
1901	25,000				250,000
1902	750	25,000	5,000		800,000
1903	9,500	10,000	3,000		1,000,000
1904	18,000		8,000		1,000,000
1905	15,000	18,000			1,000,000
1906		50,000			1,000,000
1907	5,000	50,000			760,000
1908	138,000				800,000
1909	14,000	14,000			1,000,000
1910		20,000			178,000
1911		35,000			1,000,000
1912	10,000				1,500,000
1913	25,000	15,000			700,000
1914	55,000	25,000			1,000,000
1915	30,000	30,000			1,500,000
1916	30,000	65,000			1,500,000
	683,850	1,067,000	91,000	6,000	15,688,000

UPPER SARANAC, N. Y., (Signed) MILO F. OTIS
September 30, 1916

Its total area was possibly twenty times the present size of Lake Clear and included the present St. Regis lakes as well as several others. Preceding this fossil lake there was a still much larger lake more than twenty-five miles long. The station at Lake Clear and all of the level area extending north to Gabriel's Station is a small part of the floor of this large lake.

These conditions as outlined for Lake Clear in a general way apply to nearly all of the Adirondack lakes and ponds. Using Lake Clear as a center, there are in a circle, the radius of which is fifteen miles, more than seventy-five similar ponds and lakes, many of which are restocked by the state, so that the following study may be taken as describing typical conditions in the large area of the Adirondacks.

Inasmuch as the past as expressed in the present physiography has played such a large part in influencing the present life of the lake, a brief description of the present conditions is necessary as well as the special stations at which collections were made. The names of these stations are found in Fig. 1. To these should be added the names of the two small bays, one centering at station 5, which we will name Big St. Germain Bay, and the one south of this, which we call Little St. Germain Bay.

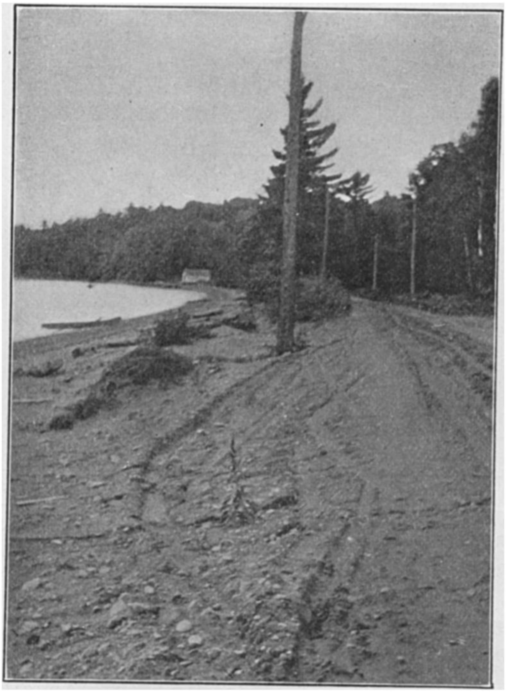

FIG. 2*a*. The shore between stations I and II. The beach is modified every spring by the ice. Note how free from vegetation this strip of the beach is clear up to the boathouse.

The plant life, the ultimate source of fish food, is limited to the area between the shore and the 15-foot contour line except for the floating algal forms. This is the part of the lake, then, that is important for our study.

From just west of station 2 to half-way between stations 4 and 5, the shoal is composed of rocks and sand. The rocks are from the glacial till and similar to the soil conditions in the "fossil" shore of Lake St. Germain as exposed by the road east of the hotel. In front of Lake Clear Inn at station 3, the glacial till and sand have been washed away, leaving a small exposure of anorthosite rock. Around stations 6 and 11 large rocks and glacial till are common. The character of the soil in these three areas determines the spawning habits of at least three species of fish in the lake. The remaining part of the shoal around the lake is wholly sand derived from the anorthosite rock. Station 7 is a sand point, designated as Spawning-bed Point on the oldest maps, although the frost fish are the only ones that are known to spawn there now.

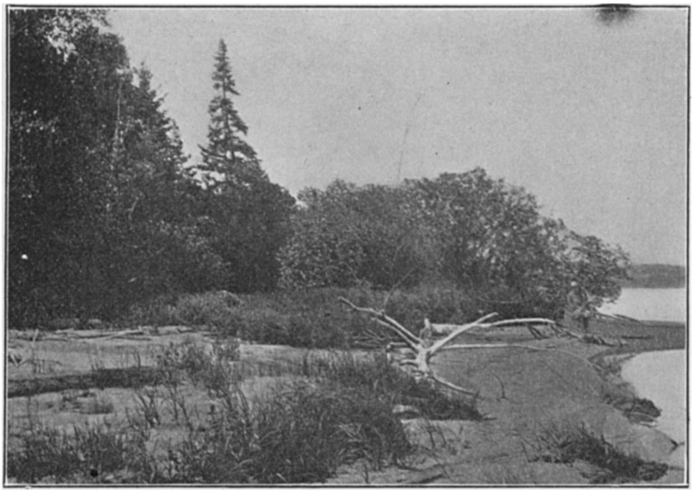

FIG. 2b. The shore opposite station XII.

The high water of early spring and the strong southwest winds cause the sand to be removed from under the trees and shrubs on the north and east shores. As the ice breaks up in May, a strong southwest wind frequently forces a large amount of ice on to the northeast shore and on the north side on to the road. On the east half of the north shore these ice-push shores form nearly every spring, to be later washed into the lake by the heavy rains of summer. These constantly shifting shores prevent permanent vegetation, thus tending to give a barren appearance to much of the shore lines, Fig. 2*a*.

The easily modified shore extending for the most part around the six miles of shore line may be taken as a good indication of the lake bottom adjacent to it. The wave action is constantly forming sand ripples which are as constantly being changed by a heavy rain or a different direction of the wind. This makes it difficult for plants to gain a foothold even if the sand were good soil for them to grow in. The general result is, then, that most of the shallow water is free from any but a very limited plant growth.

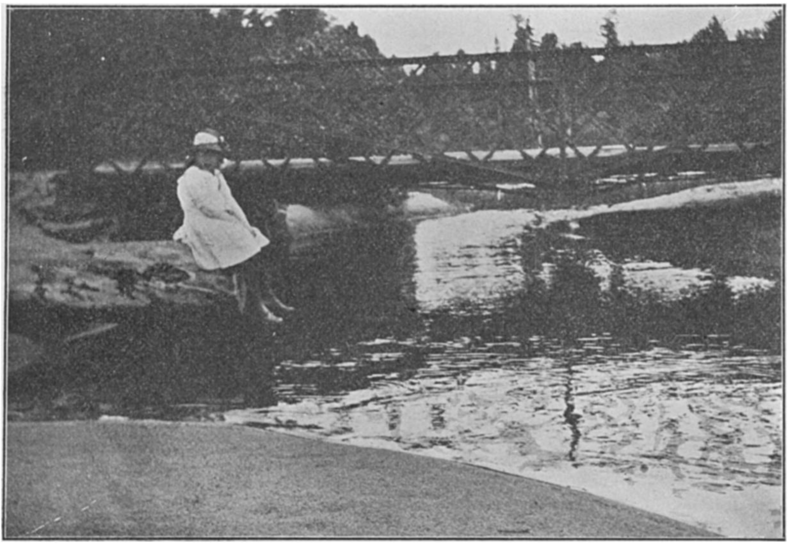

FIG. 3. Station 1, Mouth of Trout Brook. During most of the summer except after a heavy shower, the water in this stream at this place is not over six inches deep.

The largest brook, station 1, Fig. 3, receives several tributaries from Big Clear mountain and flows into the lake the year round. The remaining brooks, especially Sucker, Meadow and Tamarack, frequently become entirely dry during August. But after a severe rainstorm all of the brooks carry a large amount of water, often more than double their normal flow, for from twelve to eighteen hours, when they return to the normal again. Thus again the large amount of sand in the soil in this region plays an important part in determining how long the water shall be retained before it runs off. After these rains the water in the lake around the mouth of the brooks is colored dark by the organic matter brought down by the water of these streams. Two important results follow: First, as this organic matter settles to the bottom, a richer soil for plant growth is furnished; and, secondly, fish tend to come to these places for their food. The amount of water flowing from Trout Brook and the frequent strong winds constantly shifting the sands prevent plants from becoming established at this place. But the water is so dark here and so much cooler that this is by all means the best place to angle for brook trout, especially by fly-casting.

The summer food of fishes has been studied by so many investigators that the main facts for the several species are fairly well understood. But the more difficult problem of determining what the available food is during the winter and what fish eat during this period is still practically unknown. One naturally thinks that all aquatic life, like the deciduous trees, perhaps, enters into a resting state for several months, but that this assumption is far from correct can be shown by the following observations.

Through the courtesy of Milo Otis, superintendent of the Saranac Inn Hatchery, I have had sent to the zoology department a large number of the so-called red hydra, each month beginning with November and ending with April. These red hydra come into the hatchery tanks through the intake pipes in Little Lake Clear. These pipes are from 30 to 40 feet below the surface of the water. The important fact is clearly established that this very simple organism, sensitive to temperature changes, lives throughout the year and actively forms buds in January, February and March in the Adirondack waters. Microscopic sections of these hydra taken in February reveal the presence of minute Entomostracans in the enteron. Some of these minute Crustaceans taken from a jar containing the hydra were submitted to Dr. C. D. Marsh for identification. He reported that they were *Cyclops americana*. As cyclops is the common food of hydra we may assume that this species, which is very abundant, is eaten by these red hydra. At any rate, hydra feed on minute animals so that animal food is a prerequisite for their active growth.

The food of the cyclops in turn is the minute floating algal plants. These must be in relative abundance in order to support so many of the minute Entomostracans. Thus the conclusive proof of the active, reproductive habit of these red hydra throughout the winter establishes the winter active life of cyclops and unicellular algæ in Little Lake Clear.

These observations indicate a greater amount of vital activity in such cold regions as the Adirondacks than we had been led to believe existed. If these minute and simple forms of life live throughout the winter in an active state, we may safely predict that most of the other forms of life except the larger plants are also active and that the winter food of fishes is probably similar to that of the summer in many particulars.

During the summer of 1916, I had opportunity to observe the habits of the red hydra which are common in Lake Clear, particularly at station 12. A number of collections were made early in the summer and I attempted to bring some of the live animals back to the university, but in each instance the hydra died before reaching the city. I then tried to acclimate them to aquarium life, placing them in regular aquaria jars in the boathouse, but in each case the hydra died in from twenty-four to forty-eight hours after being taken from the lake. As they were kept in the lake water, the only explanation that seems applicable is that the water became too warm for them. During these same days, hydra were coming into the hatchery troughs at Saranac Inn and reproducing in such abundance that it was necessary to clean out the troughs every three days.

In these hatchery troughs, they grow so thick that a perfect mat is formed, covering the bottom and sides in patches two or three feet long. In the center of these patches, the hydras become brown, and, if left for about a week, may become nearly white. They look as if they were dead, but when touched, contract. Hydra taken in late September in Lake Clear were all brown, with a few that were nearly white. This wide range in color is apparently due to metabolic changes taking place in the chloroplastic corpuscles.

The red hydra are a source of food for fish, for the trout in the hatchery troughs eat them after they become a few weeks old. On first hatching, the small trout are killed by these hydra. After trout fry have eaten freely of red hydra, their droppings are colored red, indicating that the chloroplasts are not broken up in digestion. Doubtless the young fish in the lake and small minnows that secure their food from the stems of plants eat many of these hydra.

A further question arises in the relation of the fish to the several physiographic conditions in the lake. This is determined by classifying the fish habitats. These are stream, barren sandy-shoal, barren stony-shoal, vegetative and deep-water.

There is no vegetation growing in the brooks except inside the bridge of Trout Brook where *Potamogeton robbinsii* and some filamentous algæ are found. At the mouth of Meadow Brook a few bullrushes and pond lilies are seen; while the Divide Brook meanders over organic débris in which a few scattering plants of *P. robbinsii,* succeed in growing. There is a narrow fringe of yellow pond lilies about twenty feet from the mouth of this latter brook, and between the shore and this fringe of lilies a few scattered plants of the seven-angled pipewort may be seen. Ordinarily the stream habitat furnishes the most favorable ground for vegetation, yet we see in these streams a dearth of species and a limited growth that clearly indicates limited and restricted food for such animals as live upon aquatic plants.

The barren sandy-shoal, the barren stony-shoal and the deep-water habitats are each almost entirely free from plant life. This leaves the vegetative to supply the necessary food. Aside from two patches of bullrushes and two small groups of yellow lilies, the vegetative habitat is restricted to the plants that form on the slope leading to the fifteen-foot contour. At station 12, for possibly an eighth of a mile, there is a thick fringe of aquatic plants composed of *Potamogeton prealongus* and *robbinsii*. In the southeastern part of the lake and also near station 8 two other thick areas of plants occur. These consist of Potamogetons, with the addition of a third species, *P. oakesianus*. Of the possible four miles of this slope around the lake not more than one sixth supports plants.

The study of these habitats then shows that the fish are limited to the vegetative habitat in their search for such food as lives in turn upon aquatic plants.

In order to determine what the fish were actually living upon, a study of the stomach contents was made, of which the following is a summary:

Salvelinus fontinalis Mitchill. Brook Trout.—The black-striped minnow (*Leuciscus carletoni*), grasshoppers, crayfish, snail (*Campeloma decisa*), a few insect larvæ and a pumpkin seed made up the diet of the twenty stomachs examined.

Eupomotis gibbosus Linnæus. Pumpkin seed. Collected at station 8, 20 to 25 mm. long.—Daphnia and cyclops with an occasional insect larva. Fish of the same size from station 5 were feeding entirely upon daphnia and cyclops. Judging from the number found in some of these fish, I would estimate that these small fish must eat more than 1,000 crustacea daily. One specimen had more than 100 rotifers which belonged to the species of *Hydatina*. In all, about one hundred of these small fish were studied from various stations in the lake and all were found to be eating the same food, with but a small amount of individual variation. The same is equally true of the adults of this species.

Ameiurus nebulosus Le Sueur. Common Bullhead.—The bullheads in Lake Clear vary their diet, as plant remains, crayfish, clams, snails, plumatella and daphnia are all found.

Catastomus commersonii Lacépède. Common Sucker. —Plant remains, crustacean skeletons, sand, plumatella and débris are all found.

Notropis cornutus Mitchill. Shiner.—Daphnia and insects constitute their diet. A number were found with honey bees in the stomach.

Leuciscus carletoni Kendall. Black-striped Minnow.—Insect larvæ, rotifers, algæ, plumatella and daphnia were all found.

In view of the importance of the whitefish as food fish the details of this study are given.

Coregonus clupeiformia Mitchell. Common Whitefish; Labrador Whitefish.—These whitefish are by all means the most numerous fish in the lake, as from three to four thousand are taken in the fall nets at once. More whitefish are caught than all of the other species combined, so far as my observations go. One would naturally expect, then, that more of dead whitefish would be found along the shore than of any other species. If one happened to make his observations just when the whitefish are dying, the above would be correct; but not more than two or three times during a summer are any considerable number of whitefish to be found dead upon the shores. The following notes illustrate this point.

Dead whitefish collected between September 19 and 24, 1916, just as they drifted onto the north shore between the small brooks stations 1 and 2, and the East Flats, give the daily record as follows: September 19, two males, 12½ and 8¾ inches long; September 22, 4 whitefish from shore; September 23, 5 whitefish from shore; 3 others partly eaten by crows. All of these eight fish appear to be in a healthy condition and show no evidence of starvation; September 24, 5 more whitefish from shore. The intestines of three others were taken as the body of the whitefish was already mutilated by crows. During this week a strong southwest wind blew.

On July 2 and 3 a similar series of dead whitefish was found on this same stretch of shore. A dozen fish were noted, all of which were between 12 and 15 inches in length. These had all been partly eaten by crows when first observed, so that it was impossible to learn anything about their food. The crows begin their attack upon the body in the gill region and drag out the viscera through this opening. After the visceral delicacy is eaten, the dorsal muscles are gradually removed. The crows take from two to three days to eat up a whitefish. None of these twelve fish was poor or showed any sign of starvation. A strong southwest wind had been blowing for several days.

During the past ten summers I have noticed a similar series of conditions. Two or three times each summer, a large number of whitefish are found dead on the northeast shore. Occasionally, I have noticed the skeletal remains of whitefish on the west and south shores. During these irregular times when whitefish are drifting on shore, there are more of them than suckers, bullheads, brook or lake trout. Rheighard ('13, p. 224) says:

> Great numbers of dead suckers are thrown up on the beach in South Fishtail Bay in July and August. Many of these have the characteristic form of starved fish. The back is thin and sharp instead of round, and the head is disproportionately large compared to the body. . . . The emaciated fish do not appear to be diseased and are not usually parasitized heavily enough to account for their emaciation.

Colbert ('15, p. 35) names five causes of death in fishes, as follows: (1) Mechanical injury; (2) injury through attacks of other species; (3) the beaching of individuals while pursuing or swallowing prey; (4) the accidental beaching while attempting to escape enemies; (5) disease and parasites.

These are the two most important of the recent observations on death in fishes. The size and general healthy condition of the whitefish collected eliminate all but the first cause given by Colbert. It is well known that whitefish are easily killed by handling and do not have the tenacity of life so characteristic of suckers or bullheads, for example. The whitefish, although occupying the deep basins of the lake, frequently come to the surface to play. On a calm summer evening one can hear them as they spring out of the water. The splashes which they make are more numerous in the deep water, while the brook trout are seen in shallow water near the mouth of the brooks. This is a common habit of whitefish in Lake Clear, especially during July and August. That they come to the surface is also shown by the fact that at times many are caught with not more than six or eight feet of line. Their habit of coming to the surface makes it possible to see how wave actions might cause their death. None of the other causes cited by the observer quoted explains the death of these whitefish. In the detailed study it was found that all of the dead whitefish collected this summer were males, which renders it all the more difficult to understand how wave action may be the only cause of death.

The following study of the stomach contents of these dead whitefish throws a good deal of light upon their food habits:

No. 1. Male. Length 11¼ inches. Intestine full of food. Stomach contents badly macerated and most of it impossible to identify. Apparently almost entirely *Daphnia kahlbergensis*. No copepods. The mesentery contained a large amount of fat.

No. 2. Male. Length 11½ inches. Stomach and intestine contain many minute crustacean skeletons. The remains of three honey bees covered with saprolegnia. A small amount of fat in mesentery.

No. 3. Male. Length 12½ inches. Stomach and intestine contain numerous minute macerated crustacea. Mesentery loaded with fat.

No. 4. Male. Length 11¾ inches. Thousands of minute macerated crustacea in stomach and anterior part of intestine. Remains of three honey bees. Small amount of fat in mesentery.

No. 5. Male. Length 12 inches. One honey bee. No fat in mesentery.

No. 6. Male. Length 11 inches. Numerous *Daphnia kahlbergensis*. No copepods.

No. 7. Male. Length 12 inches. One honey bee. Large amount of fat in mesentery and around stomach.

No. 8. Male. Length 11½ inches. Stomach empty. Intestine partly full of digested food. Large amount of fat.

No. 9. Male. Length 11 inches. Stomach contained numerous *Daphnia kahlbergensis* and *Leptodora hyalina*. No copepods. The intestine was 5 inches long and $\frac{5}{16}$ of an inch in diameter and was packed full of cladocera skeletons.

The food in numbers 1, 6, 9 were identified by Dr. C. D. Marsh. It is probable that the minute crustaceans noted in 2, 3, 4, 8 are the same as those found in 1, 6, 9. This material was so badly macerated that it was impossible to be confident of the identification.

The large amount of food found in the stomach and intestine, and the presence of a great deal of fat in most instances, is convincing evidence that these fish did not starve to death. It seems strange that they were all males. The honey bees eaten had evidently been in the water several days, as practically every one was covered with saprolegnia.

The following whitefish were collected by Milo Otis, superintendent of the Saranac Inn Hatchery. The fish were taken during November, 1916, in nets used to secure spawning fish.

No. 10. Male. Length 11 inches. Stomach empty. Duodenum contained minute crustacea, too macerated to identify. In the intestine were found numerous winter eggs of *Daphnia*. These winter eggs appear to be uninjured by the digestive enzymes. Some were found in the rectum in a perfect condition, so that I feel confident that most of them pass through the digestive canal and into the water ready to grow into *Daphnia*. This is an important fact when the problem of an adequate amount of food is taken into consideration.

No. 11. Female. Length 11½ inches. Stomach empty. Macerated cladocera in intestine. Many tapeworms present.

No. 12. Male. Length 11½ inches. Stomach empty. Intestine contains macerated cladocera. Very fat.

No. 13. Female. Length 11 inches. Stomach and intestine mostly empty. Parasites present. Ovaries full of eggs.

No. 14. Male. Length 11 inches. Stomach empty. Intestine with cladocera skeletons. Parasites present.

No. 15. Female. Length 8½ inches. Stomach and intestine empty. Cœlome full of eggs.

The following viscera taken from whitefish collected by Milo Otis were received November 24, 1916:

No. 16. Stomach empty. Several parasitic flatworms present.

No. 17. Stomach contained 3 pumpkin seeds (*Eupomotis gibbosus*) 1 inch long; 1 partly digested *gibbosus;* 1 snail (*Amnicola Limosa* Say identified by F. G. Baker). Parasitic flatworms present.

No. 18. Stomach contained many *Daphnia kahlbergensis* and *Leptodora hyalina.* No copepods.

No. 19. Stomach contained numerous *Daphnia* winter eggs; 8 whitefish eggs.

No. 20. Stomach full. One pumpkin seed (*Eupomotis egibbosus*) and 103 whitefish eggs. Parasitic flatworms present.

No. 21. Stomach empty, with many parasites.

No. 24. Stomach full of whitefish eggs.

No. 25. Stomach contained 1 partly digested fish, probably *gibbosus.*

Nos. 26, 27. Each contained many *Daphnia.*

No. 28. Stomach contained *Daphnia* and whitefish eggs.

In the jar containing the viscera of the whitefish numbers 16 to 28, there were, in addition to the above records, 20 pumpkin seeds that had been in some of these stomachs and 107 whitefish eggs. 33 tapeworms were also found in this residue.

Small pumpkinseeds were selected in order that the food habits of very young fish might be compared with the adults. Small fish 20 to 25 millimeters (about an inch), 25 to 30 millimeters, and adults 100 millimeters long (3 to 4 inches) were examined.

These young fish live almost exclusively on small cladocerans, with cyclops and daphnia predominating. Occasionally one was found having only rotifers. Insect larvæ do not play an important part in their food so far as my studies go. The adults include, in addition, plants and *Plumatella.*

Baker (1916, pp. 184–188) gives a summary of the facts of the food habits of this species in which insect larvæ and mollusca are seen to be the most important. In Walnut Lake, Wisconsin, insect larvæ are mainly eaten;

while in Douglas Lake, Michigan, and Oneida Lake, New York, molluscs are the more important. In Lake Clear, cyclops and daphnia may be said to be their main food. These two animals happen to be almost the only food of the whitefish. The pumpkin seeds in Lake Clear thus become a hindrance in the stocking of this lake. The number of pumpkin seeds eaten by other fish does not appear to be large. It is suggested that food fish which live harmoniously with whitefish but feed upon pumpkin seeds would make a valuable combination.

Forbes (pp. 108, 1883) made numerous experiments to determine the natural food of young whitefish. He found that cyclops were more important than all the other organisms combined. Hankinson (p. 239, 1914) also noted the almost exclusive diet of cyclops and daphnia. Baker (pp. 159–161) shows that not only crustacea, but molluscs are important as food for adult whitefish. My observations emphasize the limited diet of large whitefish in Lake Clear where cyclops and daphnia are all that are eaten during the summer. In the fall some specimens were taken with the snail *Amnicola* in the stomach, but this snail is present in limited numbers only, so can not be very important as a source of food in Lake Clear. During the fall, small pumpkin seeds and their own eggs are added to the daphnia-cyclops diet. It is to be noted that all of the dead whitefish were in good condition, most of them being fat. These all fed upon the daphnia-cyclops diet.

These cladocerans produce winter eggs in large numbers which are not destroyed by the digestive juices of the whitefish nor the other fish that feed upon them. These eggs pass through the entire digestive canal uninjured. This is an important factor in keeping up the number of these minute organisms. Were these winter eggs digested and used as food, it is probable that this, the most important source of food for whitefish, would soon become exhausted.

The brook trout taken in Trout Brook or at its mouth feed for the most part on insects; while those taken in the lake eat minnows almost exclusively. The two taken early in the spring (the ice did not break up until after May first) had been feeding upon pumpkin seeds, crayfish and insect larvæ. No molluscs were found.

The food of the three species of minnows examined as well as the suckers indicates that these fish live largely on the same animals as the whitefish and the pumpkinseeds. The bullhead is the most general in its diet of any of the fish studied, taking clams, snails, crayfish, minnows and plants.

A detailed study of the food habits of the fish in any lake is necessary before one can tell just what the several species of fish actually eat. It is to be regretted that in this lake the number of organisms suitable for food for fishes is so limited. The result is that each species comes into competition with the other species for food. *The result of this competition for the one abundant food, daphnia-cyclops, prevents this lake from permanently having large numbers of food fish.*

The consideration of the history of the lake, the specific habitation of the fish, the noteworthy dearth of aquatic plants, the actual food of the fish and the restocking that has taken place during the past thirty years leads to the conclusion that restocking has not been and cannot be a success. In estimating how many fish any given body of water will support, one must first consider the variety and abundance of aquatic plants. *There can not be any more animal food for the small fish and fingerlings than can find subsistence on the aquatic plants of any given body of water.*

In this connection a second question might be asked, why stock any Adirondack pond with a distinctively food fish? Whitefish when not taken in nets are caught at baited buoys which are placed early in the spring by the local fishermen. I have counted 25 buoys scattered around the lake in early June. At these buoys a considerable number of whitefish are taken by relatively very few people, probably not over fifteen separate families. Sportsmen who desire to fish for whitefish employ some one who has a buoy located advantageously as a guide. This guide ties the boat to his buoy. In a half day, from six to twenty whitefish may be thus taken. No one is expected to tie to one of these buoys without the "owner's" consent. The result then of this extensive stocking by the state has been to enable a few local families and guides to catch for their own use and to sell a few whitefish. The general vacation transients are not benefited nor is this excellent food fish taken in such numbers as to yield any considerable amount of food. If the state is to continue to restock such ponds as Lake Clear with whitefish, then some better method should be devised to take the whitefish.

The fundamental reason why the extensive restocking of Lake Clear has not been a success is due to the glacial origin of the lake. The mere fact that the sand in which the plants try to grow has been resorted by the glacial waters until most of the organic material, plant food, has been washed away, produces a very limited number of aquatic plants. Such plants are indispensable as a source of food for the numerous minute organisms upon which fish normally feed. One can hardly appreciate what a large number of different animals fish eat unless he has given careful study to this problem. Baker (pp. 157–199) gives a summary of the different kinds of animals eaten by fish and the variety is in striking contrast to the one abundant group of organisms (daphnia-cyclops) in Lake Clear. In order to have a general growth of fish in a lake, I believe that an abundance of *several kinds* of fish food is indispensable. The conditions in Lake Clear well illustrate how the species that can most successfully utilize the form of food that is abundant survives and greatly increases in numbers, while the others remain few in numbers.

The shores of Lake Clear are remarkably free from dead fish and one rarely finds any dead fingerlings. It would seem as if there were but one conclusion, namely, that the most of the fingerlings are eaten by larger fish.

The probabilities are that there would not, then, have been any more trout in Lake Clear, even if the state had placed many more than it has during the past thirty years. This lake really illustrates an instance of overstocking simply because there was not an adequate amount and variety of food. At present there does not seem to be any way to remedy this deficiency.

During the past summer the states have been urged to increase greatly their production of food and game fish. This very general recommendation fails to recognize certain fundamental facts. The next step in advance along fish propagation is one that will have to be taken slowly, as it necessitates a great deal of critical information. It is becoming more and more apparent that we must not only know the breeding habits of the small minnows, pumpkin seeds, etc., the fry of which serve as admirable food for the food-fish fingerlings, but also the natural history of all of the life of a given body of water. It is a well-recognized biological axiom that no organism can live unto itself alone. This applied to our problem means that a clear and adequate supply of water is not the only factor that must be considered in deciding to restock great bodies of water with fish-fry. But rather the intricate and more or less obscure conditions that determine the sum total of life in each body of water must be taken into consideration. Such studies alone furnish a correct basis for determining the extent to which an animal may draw upon a given source of food, upon the available body of food, and many kindred problems. Before the state can wisely undertake to place more fingerlings in the ponds, it ought to know whether there is enough available food to keep them at least from starving.

The extensive restocking of most of the Adirondack ponds is done mostly for the benefit of the sportsmen. The benefit that has accrued to these and many other vacationists is very great, but one can not help wondering if this policy should not be restricted and adjusted. One or two trout hatcheries would probably be able to produce all of the trout needed, while the rest might be turned over to the production of food fish which should be placed in the larger bodies of water that support an abundant aquatic plant life. The conditions in Oneida Lake are in such striking contrast to those in the Adirondacks that one can unhesitatingly suggest that this lake could support an incredible number of fish.

Intimately associated with this general problem is the question of disease in fishes. Under this heading are included the several forms of parasitism. Reference will be made to two or three only. This is the field in which the greatest progress has been made in the cure and prevention of the diseases affecting man. But before *prevention can be applied, the life history of the parasite must be understood.* In the main, the work of the national and state governments has been confined solely to hatchery problems. Here is a field that they should enter, as many of the problems are too large and involve too much expense for the individual.

Salmincola edwardsii (Olsson).

This parasite belongs to the copepod group of crustaceans, many of which are familiarly known as "fish-lice." Wilson says: "This family (Lernæopodidæ) of parasites is widely distributed amongst fishes in both salt and fresh water. Some of our best food and game fish are infested with them, and when they once obtain entrance to a stock pond, fish hatchery, or aquarium they usually multiply so rapidly as to become a serious nuisance, and may even kill the fish" (p. 569). There are some one hundred and thirty-six different species of animals that belong to this family, all of which are parasitic during their adult life. In the genus to which our specimens belong, there are twenty species, eighteen of which live exclusively upon the several kinds of trout.

Salmincola edwardsii is found exclusively infesting the brook trout (*Salvelinus fontinalis*). All of the specimens taken in Lake Clear were attached to either the dorsal or anal fin. The gills of these fish were examined but no fish-lice noticed upon them. This seems strange as Fasten (1911–12) reports them as especially abundant upon the gills. They were found on trout ranging from four inches in length to those fourteen inches long, which were caught in Trout Brook, in the lake near the mouth of this inlet, station 1, and in the bay near station 5. They were taken upon both large and small fish in each of these locations. My specimens were collected during July, August and September. The last specimens were on a nine-inch male caught in Big St. Germain Bay, September 28, 1916. The egg-sacs were full of embryos.

This common "fish-louse" is easily recognized. From the main part of the body two large egg-sacs are suspended. With an ordinary hand lens, the numerous small embryos can be noted, and the small beak which attaches the parasite to its host. Fasten has recently worked out the life history and the habits of this interesting parasite, which undergoes an extensive degeneration after becoming parasitic.

These parasites are widespread in the United States in the native trout streams, and in Canada and Europe. The first scientific record of this particular parasite is by Linnæus in 1761. It seems strange that an animal could be known for so long and its habits not be understood until within the past five years. The fact that it is so widespread and has been known for so long indicates that it is not a serious pest except under very favorable living conditions. These are best found in the hatcheries or stock ponds, where many fish live in a small enclosure. The numerous parasitic larvæ then have little trouble in finding a host. In the streams and ponds of this state, we need not fear that the trout will be killed by them. The chief reason is that the trout are few in numbers in any given place, so that when the embryo parasites make their escape, there is small chance of their ever becoming attached to a trout. The result is that each trout in a wild state does not usually harbor more than a half dozen, and this number does no serious harm to the trout, especially where they are attached to the fins.

When this pest gets into a hatchery, but little can be done. The infested trout at the Wild Rose Hatchery in Wisconsin were treated with "solutions of copper sulphate, potassium chlorate, sodium chloride, and mixtures of sodium chloride and potassium chlorate, but these had no effect upon the parasite" (Fasten, 1911–12, p. 17). About the only remedy that is effective is to destroy all of the parasitized trout, which can be done after the spawning season; for there is no reason to believe that these parasites can be carried from one place to another except in the manner described by Fasten. We do not know how these parasites pass the winter, but in view of the fact that they are not known to eat during their free-swimming period, it is probable that those which live through the winter do so as parasites upon trout. During the cold weather the growth changes would not take place as rapidly, so that a given parasite might remain on a trout for five or even six months during the winter.

Clinostomum marginatum.

This is a small Trematode that lives for a part of its life embedded in the muscles of several food and game fish. The popular name of "grubby" is used to describe this condition. So little is known about this parasite that renders thousands of dollars worth of fish unsuitable for food that any new facts are welcome. In this connection, the following field observations are recorded upon this very annoying parasite. In an earlier paper (Smallwood, '14) attention was called to the fact that these worms may voluntarily leave the body of their host after the host dies. On May 28, 1914, about 50 perch were taken from McCauley Pond between Saranac Lake village and Lake Clear Junction. After returning to camp, it was noticed that these perch were "grubby" and they were all left in a pile on the ground. The next morning, I examined the pile of perch and was able to pick up more than 100 flatworms that had crawled out of their cyst during the night. If I had cared to do so I could have gathered several hundred specimens during the day as they continued to escape from the cysts.

This observation answers one question, namely, that these parasitic worms remain in the body of the perch all winter, as the worms were in the same stage of maturity as those taken in July, August and September. It further suggests, also, that *Clinostomum marginatum* may return to an aquatic habit directly from the body of the fish.

Guides and fishermen claim that perch are free from ''grubs'' at certain seasons of the year, a belief which I am unable to confirm. But if more extended studies show that their belief is true, the method by means of which the ''grubs'' leave the fish has been found.

So far as we know, these parasites are mainly confined to members of the bass and perch families, although a few cases are on record of trout being infested with them. Occasionally one finds a few bullheads that are ''grubby.'' In Lake Clear *Lepomis gibbosus* and the minnows are largely infested by them.

I can also confirm my observations (p. 11, '14) that fish eating parasitized minnows are not themselves infected through this avenue. One brook trout was found with a partly digested minnow in its stomach. In the flesh of the minnow a dead parasitic clinostomum was observed.

I would say that the number of fish harboring this parasite in Lake Clear is on the increase.

The following observations upon some larval stages in Trematodes may help to start some one upon this problem without losing a season experimenting.

During the past three years, I have frequently found in the muscles of perch and pumpkin seeds minute cysts. Each of these cysts contains a larval Trematode.

The wall of the cyst is tough and easily ''shells out'' of the muscles, but is not readily penetrated by the ordinary killing fluids. This has resulted in my not being able to secure suitable sections for detailed study. It will probably be necessary to make most of the observations upon living material, which will require that one have a microscope and microscopic reagents while doing field work.

The following general facts may help to direct attention to this important stage in the development of the life history of Trematodes. Possibly, some fish containing them may be found near a laboratory and thus readily studied.

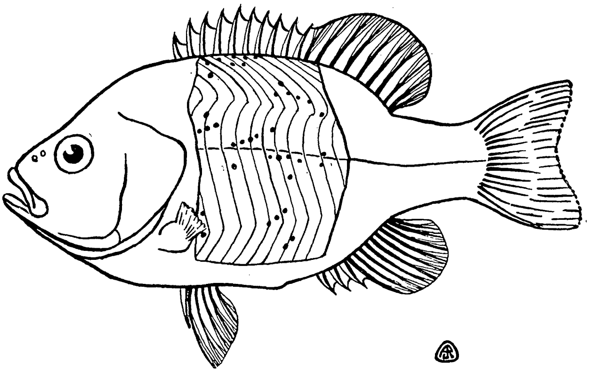

FIG. 4. *Lepomis megalotis* (Rafinesque), long-eared sunfish. Taken in Lake Clear, 1915. A portion of the skin has been removed to show the position that the larval stages of certain undetermined Distomes occupy in the flesh.

Fig. 4 shows the usual position of these larval stages in the muscles of the long-eared pumpkin seed taken in Lake Clear during July, 1915. Each cyst is accompanied by a small amount of pigment in the more advanced stages, although I have seen many of them with no pigment and nearly the same appearance as the muscle (Fig. 7). One must often pick the muscle fibers apart in order to find the cyst as most of them do not show on the surface. I have not been able to discover that they are found in any definite region of the body, although they are more numerous near the dorsal fin.

A photomicrograph of a young cyst shows a number of blood vessels entering one end of the cyst. The cyst itself contains numerous blood corpuscles, as if they had been emptied into the cyst. The difficulties of fixation have prevented me thus far from studying the character of the blood in these cysts.

As the cyst grows, the wall of which is made up of connective tissue, partitions are formed which grow in from the main outside wall. The result is that in the older stages three to five separate cavities are found in each cyst (Fig. 6), although but a single larval Trematode is present in each cyst. I have opened a large number of these cysts and thus far have found no exceptions.

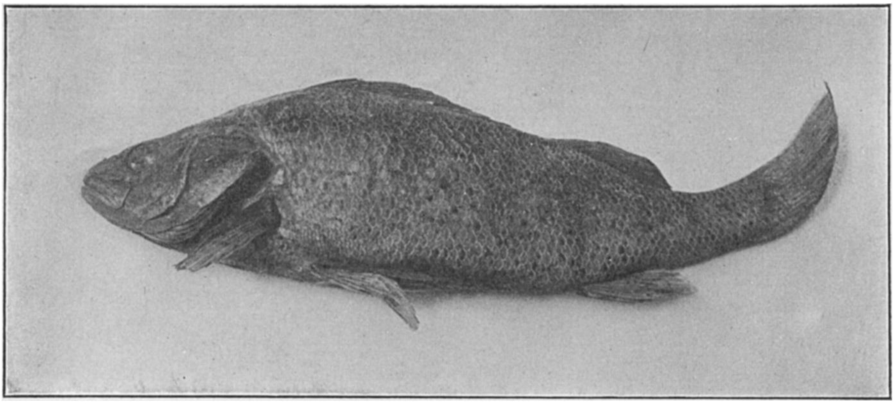

FIG. 5. The perch (*Perca flavescens*) showing minute distomes embedded in the skin and fins. These parasites can be recognized in the photograph as minute, black spots. The black pigment surrounds the parasite.

Not much can be said at this time in regard to the structure and changes through which this larva is passing. That it is growing there can be no doubt, as different stages showing the presence or absence of some of the mature organs were found. In most of the whole larvæ dissected and mounted, the excretory ducts are completely formed, while the digestive tract is limited chiefly to the anterior end. Two suckers can be recognized and a part of the reproductive organs. The whole animal is so very small that it can scarcely be seen with the unaided eye. It will require better fixation before the species can be determined accurately. I am inclined to believe that it is the larval stage of either some species of *Holostomum* or *Clinostomum*. The latter is more numerous in this lake; but the size and pigment strongly suggest *Holostomum*, the adult appearance of which is shown in the photomicrograph (Fig. 7).

From the studies thus far made, I am inclined to think that it takes one season for this larva to transform into the adult worm. My reason for this conclusion is that there is so little difference between the several stages that I have secured.

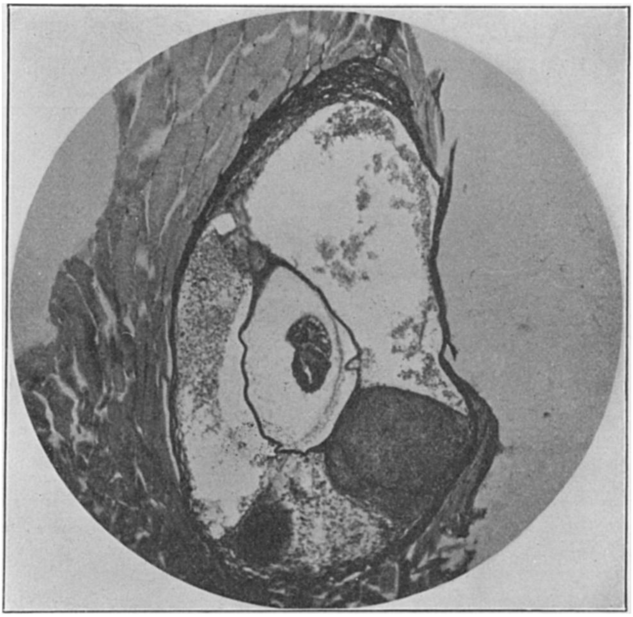

FIG. 6. Photomicrograph of the larval cyst of an undetermined distome. Each cyst contains but a single young worm, although there are several partitions. The cyst is surrounded by several layers of connective tissue and is embedded in the muscles.

In the hope of throwing some light upon the relation of Trematodes to fish, the writer urged several years ago that some "grubby" perch be placed in a separate tank in one of the hatcheries and fed for one year to see what happened, but the suggestion was rejected as not practical, although a number of specific experiments were outlined. It is unnecessary to say that many thousands of dollars' worth of fish would be rendered available throughout the United States, if this one disease alone could be prevented. Perch and bass which are so generally infected with Trematodes are delicious pan fish and usually easily caught in large numbers. It would seem as if the mere calling attention to this large amount of food annually wasted would stimulate some organization to finance the necessary scientific investigation. Such an investigation would need to continue at least two years and possibly longer; but the expense involved would be a small fraction of the returns, if the disease could be prevented.

"Grubby" perch are but one illustration of the diseases that occur in our fresh-water fish. There are a number of diseases due to bacteria and others caused by certain Soporozoa, Fig. 7. These diseases are usually epidemic, killing large numbers of fish in a few weeks. The main fact that is known now is that the fish die and several specific microorganisms are observed to be associated with certain ulcers, cysts, etc. But as to what causes lead up to the fatal termination of the diseases, little is known.

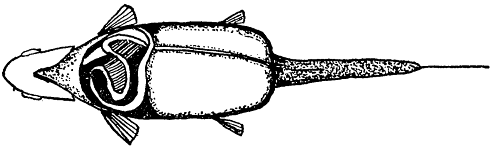

FIG. 7. *Leuciscus carletoni* (Kendall), black-stripped minnow. Taken in Lake Clear, 1916. Infected with *Myxobolus*, a sporozoan parasite.

An admirable monograph upon carcinoma of the thyroid in the Salmonoid fishes was prepared, but left incompleted because of lack of funds. This is about the only serious study of fish diseases that has been made in the United States.

At this time, when all are anxious to help in whatever way that they can, it may be permissible to suggest that scientists may render real service along the general lines indicated in this paper. To be more specific, they may be summarized as follows:

1. A critical study of the life of the fresh-water ponds and streams is very desirable.
   - (*a*) To determine the life history and food habits of the small fish and invertebrates present.
   - (*b*) To determine the amount and conditions of plant life—the ultimate source of food for all animals.
   - (*c*) To determine if more plants can be made to grow in water naturally lacking sufficient plant life.
   - (*d*) To determine if it is possible to introduce enough natural food for fry and fingerlings to keep them from starving, as many of them probably do now in such ponds as many of those in the Adirondacks.
   - (*e*) To determine to what extent the natural food of the fish is eaten by invertebrates living in the same waters.

When these problems are solved, the next step in efficiency in fish culture can be taken. It will require the cooperation of many scientists. The result will be the substitution of an intelligent method of restocking in place of the present one, which is often unintelligent or politically influenced.

2. A detailed study of the several diseases occurring in fish.
   - (*a*) It is necessary to know the complete life history of such parasites as the Trematodes before any one can formulate preventive measures. There are at present at least four different species of Trematodes found in our fresh-water fish and the complicated life history of each is unknown.
   - (*b*) The causes leading up to the usual epidemics in fish must be determined before these can be prevented. This is a problem for the bacteriologist and the protozoologist.

When these problems are worked out, an enormous amount of fish food will be conserved for human needs.

SYRACUSE UNIVERSITY,
October 29, 1917

BIBLIOGRAPHY

The following list of references includes only those works cited in the preceding pages. A more extended reference to the literature will be found in F. C. Baker's paper, which is the first one given in the list below.

Baker, Frank Collins.

1916. The Relation of Mollusks to Fish in Oneida Lake. Technical Publication No. 4. The New York State College of Forestry at Syracuse University, pp. 1–366.

Bean, Tarleton H.

1903. Catalogue of the Fishes of New York. Bull. No. 60. New York State Museum, pp. 1–784.

Calkins, Gary N.

1899. Report upon the Recent Epidemic among Brook Trout (*Salvelinus fontinalis*) on Long Island. Fourth Annual Report of the Commissioners of the Fisheries, Game and Forests of the State of New York. Report for the year 1898, pp. 175–189.

Colbert, Roy J.

1915. An Ecological Study of the Fish of the Douglas Lake Region, Michigan, with special reference to the mortality of the species. Michigan Geological and Biological Survey. Publication No. 20, Biology Series No. 4, pp. 25–57.

1911–12. The Brook Trout Disease in Wisconsin Waters. Report of the Wisconsin Commission of Fisheries, pp. 11–21.

1913. The Behavior of a Parasitic Copepod. *Jour. Animal Behavior,* Vol. 8, pp. 36–60.

1914. Fertilization in the Parasitic Copepod, *Lernœopoda edwardsii. Biol. Bull.,* Vol. 27, pp. 115–121.

Fenneman, N. M.

1910. Lakes of Southeastern Wisconsin. Published by the State of Wisconsin.

Forbes, Stephen A.

1883. The First Food of the Common Whitefish (*Gorogonus clupeiformis* Mitchill). Bull. Ill. State Lab. Nat. Hist., I, No. 3, pp. 95–110.

Gaylord, H. R., and Marsh, M. C.

1912. Carcinoma of the Thyroid in the Salmonoid Fishes. Bull. Bur. Fisheries, Vol. XXXII, 1912. Document No. 790. Issued April 22, 1914.

Gurley, R. R.

1894. The Myosporidia or Psorosperms of Fishes, and the Epidemics Produced by Them. U. S. Commission of Fish and Fisheries. Commissioners' Report, 1892, Published 1894. Pp. 65–359.

Hankinson, Thomas L.

1914. Young Whitefish in Lake Superior. *Science,* N. S., Vol. 40, No. 1024, p. 239.

1915. Observations on the Fishes of Houghton County, Michigan. Michigan Geological and Biological Survey. Publication No. 20, Biological Series No. 4, pp. 11–22.

Needham, J. C., and others.

1903. Aquatic Insects in New York State. Bull. 68. New York State Museum.

Needham, J. C., and others.

1905. May Flies and Midges. Bull. 86. New York State Museum.

Reighard, Paul.

1908. A Plan of Promoting the Whitefish Productions of the Great Lakes. Bull. U. S. Bureau of Fisheries, XXVII, pp. 643–84.

Smallwood, W. M.

1914. Preliminary Report on Diseases of Fish in the Adirondacks. A Contribution to the Life History of *Clinostomum marginatum.* Technical Publication No. 1. The New York State College of Forestry at Syracuse University, pp. 1–27.

Smith, Henry I.

1874. The Crustacean Parasites of the Fresh-water Fishes of the United States. U. S. Fish Commission. Report for 1872–73.

Wilson, Charles B.

1915. North American Parasitic Copepods Belonging to the Lernæopoda, with a revision of the entire family. No. 2063. Proceedings U. S. National Museum, Vol. 47, pp. 565–729.